

TM 8094

**0.4- 3.4 GHz
Converter**

INSTRUCTION MANUAL



MARCONI INSTRUMENTS

Instruction Manual

No. EBM 8094

for

0.4- 3.4 GHz Converter

TM 8094



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MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND



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0.3-3.3 GHz Converter, TM 8094

1.1 INTRODUCTION

The 0.4 - 3.4 GHz Converter, TM 8094, is a plug-in Function unit designed for operation with a TF 2401 series Counter and a 110 MHz range unit. The converter allows frequency measurement on C.W. within the coverage of the range unit and from 0.402 to 3.404 GHz.

This Function unit comprises the B input channel, and the function switch which controls the d.c. signals fed to the gating in the Range

unit and basic instrument. Totalizing measurements can also be made. There is also a self-test position on the function switch for checking the operation of the dividers and decade counting units.

The unit works on a heterodyne principle; the input is mixed with a harmonic of 100 MHz from the 1 MHz counter standard signal, this harmonic being selected by tuning a resonant cavity. The resultant difference frequency is fed to the counter and the input frequency determined by the sum of the mixing frequency and the counter reading.

1.2 DATA SUMMARY

HETERODYNE

FREQUENCY RANGE:

0.402 GHz to 3.404 GHz.

INPUT SENSITIVITY:

Better than

-7 dBm from 402 to 604 MHz,

-13 dBm from 0.604 to 2.504 GHz,

-7 dBm from 2.504 to 3.404 GHz.

MAXIMUM INPUT:

1.0 V r.m.s.

ACCURACY:

As TF 2401 series counter.

INPUT IMPEDANCE:

50 Ω nominal.

LEVEL INDICATOR:

Meter indicates tuning and minimum input signal level required.

VIDEO

FREQUENCY RANGE:

1 MHz to 100 MHz.

INPUT SENSITIVITY:

10 mV r.m.s.

ACCESSORIES:

supplied: 1 x free plug, type N.

2.1 INSTALLATION

The space in the basic counter provided to accept the Function unit is shown on the illustration in the counter manual. The unit is easily installed by locating it in its guide channel and pushing it slowly to the rear of the counter until it locks with its mating connectors. Once firmly in position secure the unit by using the locking screw provided at the front of the unit.

2.2 CONTROLS AND CONNECTORS

① **FUNCTION** switch. Sets the instrument for the desired operating mode.

② **INPUT B** connector. Type N socket for B input signal; input must not exceed 1 V r. m. s.

③ **Tuning control**. Selects the harmonic of 100 MHz (derived from the counter's 1 MHz standard) to be mixed with the input signal. Dial is calibrated in GHz.

④ **Meter**. Maximum deflection indicates correct tuning of converter; pointer exceeding MIN mark shows that there is sufficient output to drive rest of counter system.

2.3 CONNECTING INPUT

Input connections must be shielded, by the use of coaxial cable, to prevent noise pick-up.

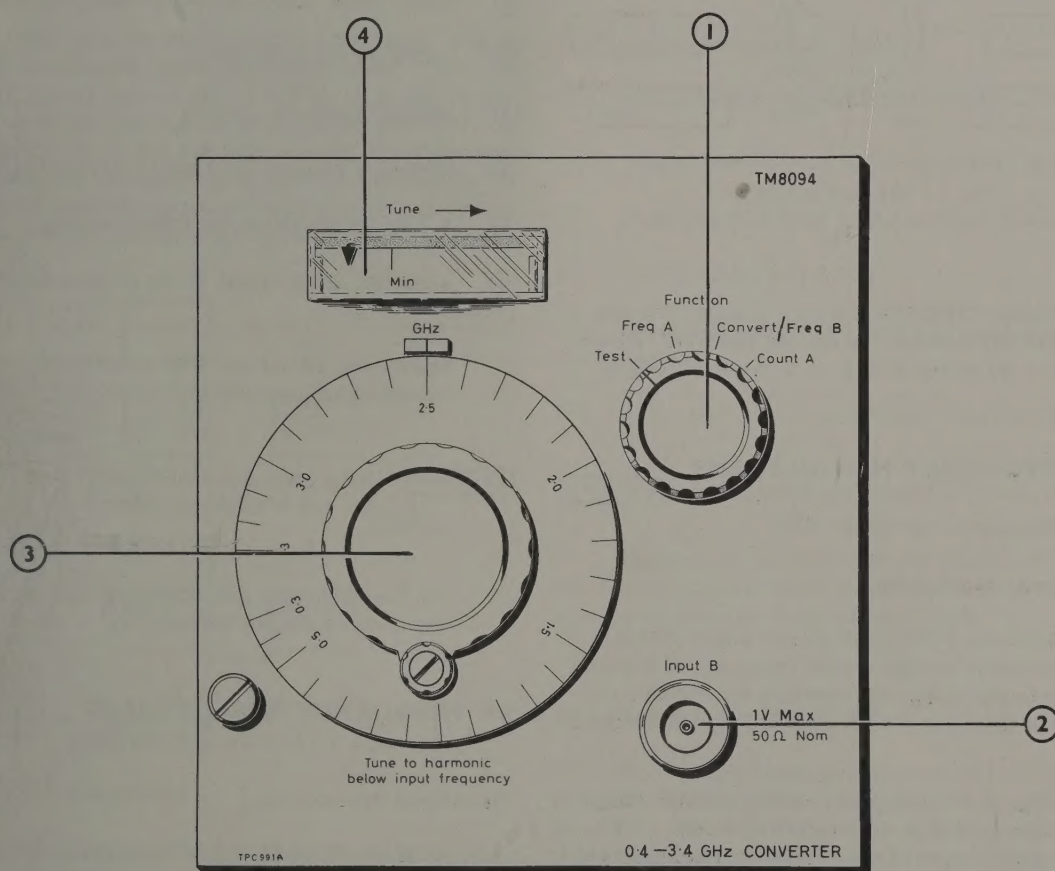


Fig. 2.1 Controls and connectors

2.4 SELF-CHECK TEST

The instrument self-checks the time base and decade counting units. Following installation, and from time to time, the self-check should be employed as follows:

- (1) Set FUNCTION switch to TEST.
- (2) Set GATE switch to AUTO.
- (3) Set DISPLAY control and MEMORY switch for desired display mode.

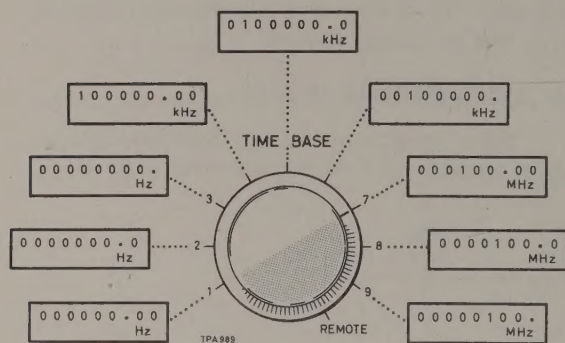


Fig. 2.2 Self-check test readout

- (4) Rotate TIME BASE switch through its nine positions and observe the decade readouts, which should be as shown in Fig. 2.2 above (± 1 count).

2.5 FREQUENCY MEASUREMENT

(For frequencies up to 110 MHz)

Functional description

With the FUNCTION switch set to FREQ A, the instrument measures the frequency of a signal applied to the A input by counting the number of cycles of the input over a selected period of time.

Fig. 2.3 shows a simplified function diagram of the instrument in this operating mode. The signal gate is opened and closed by a selected output of the time base as controlled by the TIME BASE switch. During the time that the gate is open the input signal is passed through the gate to be counted by the decade counting units.

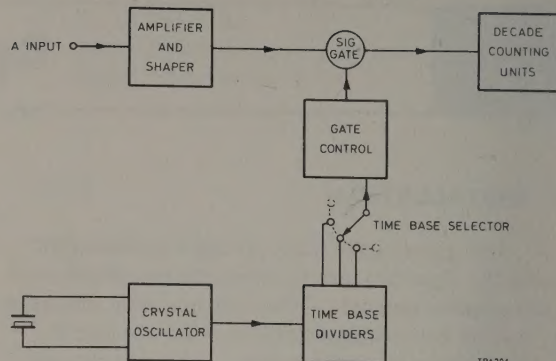


Fig. 2.3 Functional diagram for frequency measurements within limits of range unit being used

Operating procedure

Set the controls as follows:

- ① FUNCTION switch to FREQ A.
- ⑤ TIME BASE switch to the desired position.
- ⑥ GATE switch to AUTO.
- ⑦ MEMORY switch to OFF.
- ⑧ DISPLAY control for a short display time.
- ⑨ A ATTENUATOR to maximum setting.
- ⑩ Apply the input signal to the A input connector.

Reduce the attenuator setting until the counter gives a consistent readout.

CAUTION

Input must not exceed 100 V r.m.s. for 110 MHz Range unit.

Set the MEMORY and DISPLAY control for the desired display mode.

2.6 FREQUENCY MEASUREMENT

(in range 0.302 GHz to 3.404 GHz)

Functional description

With the FUNCTION switch set to CONVERT B, the instrument measures the frequency of a signal applied to the B Input by counting the number of cycles of the difference between the input and a harmonic of 100 MHz, over a selected time interval.

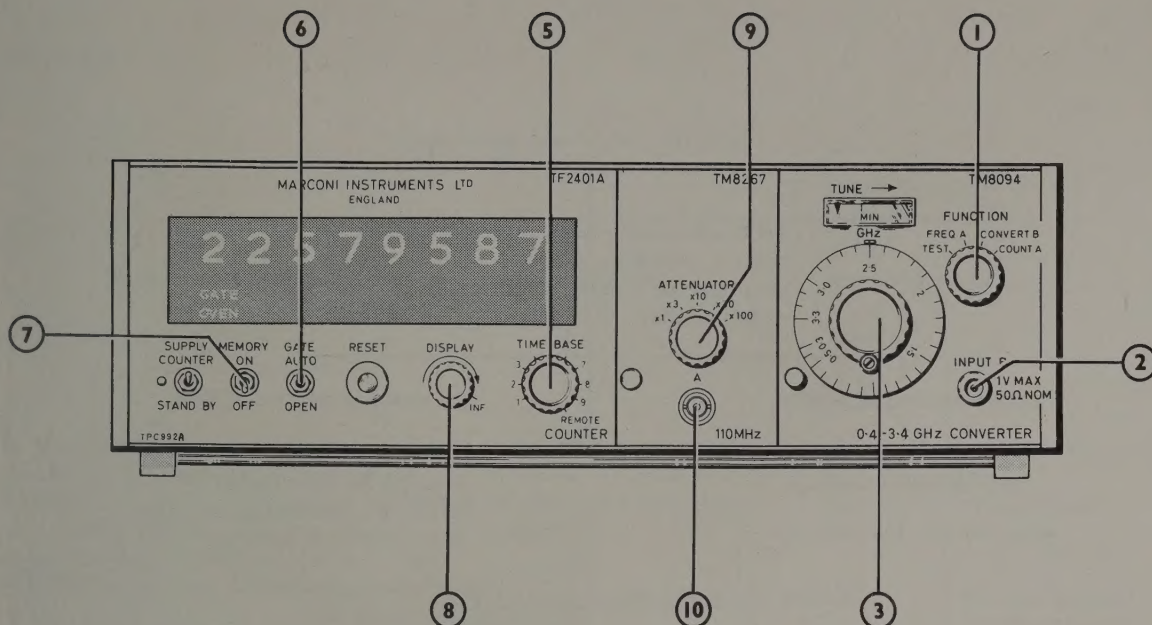


Fig. 2.4 shows a simplified functional diagram of the instrument in this operating mode. The signal gate is opened and closed by an output of the time base selected by the TIME BASE switch. During the time that the gate is open, the difference frequency of the input signal and the selected harmonic of 100 MHz is passed through the gate to be counted by the decade counting units.

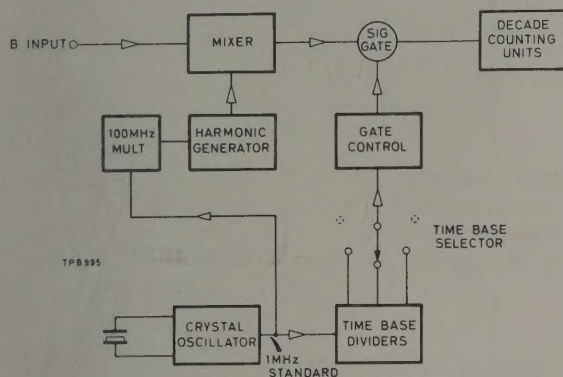


Fig. 2.4 Functional diagram for CONVERT B function

Operating procedure

Incorrect readings may be obtained by tuning to the wrong harmonic of 100 MHz or by mixing with a harmonic of the input frequency. The correct reading will always be obtained if the following procedure is adhered to.

Set the controls as follows:

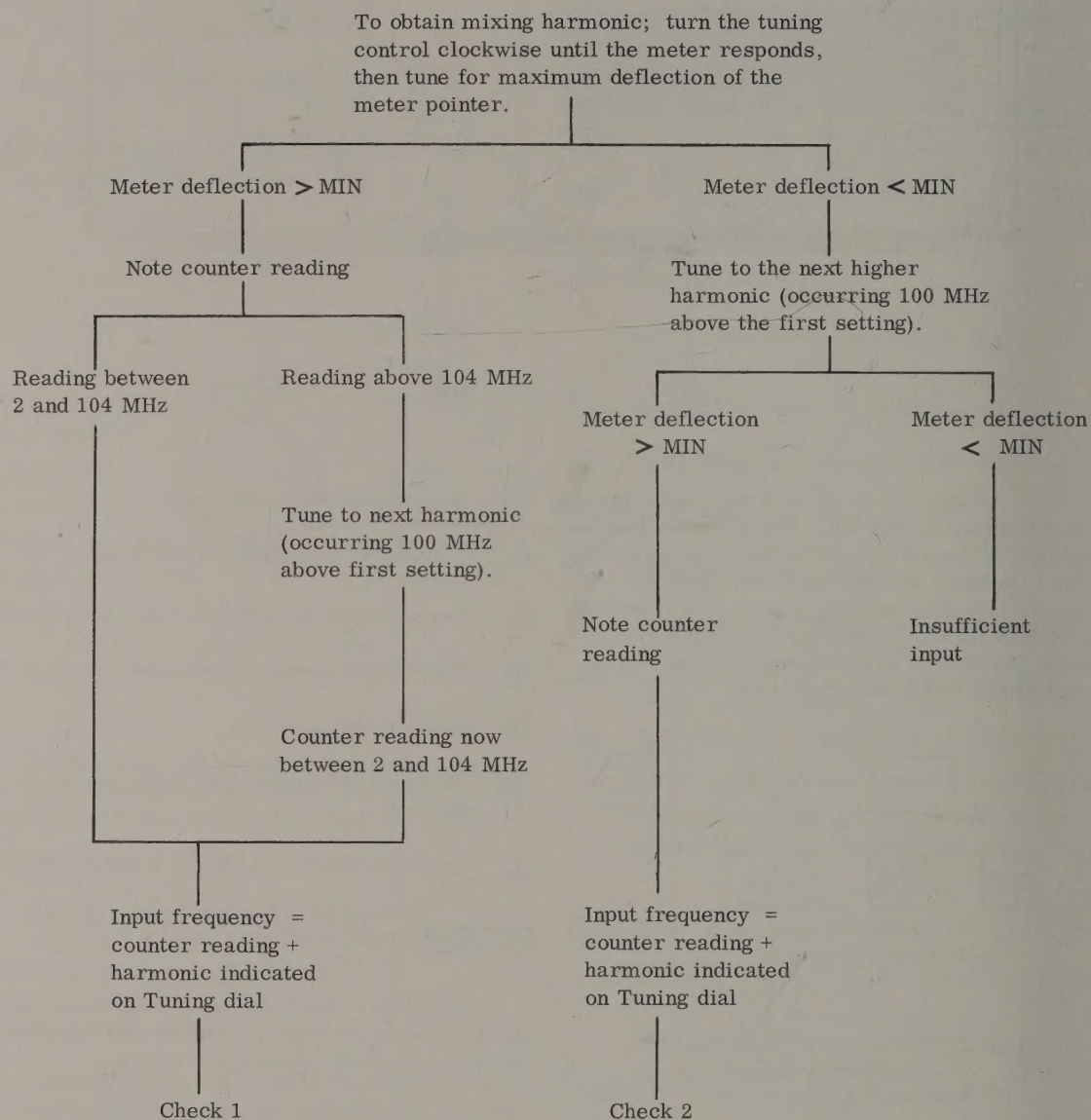
- ① FUNCTION switch to CONVERT B.
- ③ Tuning control to minimum reading (0.300 MHz).
- ⑤ TIME BASE switch to the desired position.
- ⑥ GATE switch to AUTO.
- ⑦ MEMORY switch and DISPLAY control as desired.
- ⑧ Apply the input signal to the B Input connector.

CAUTION Input must not exceed 1 V r. m. s.

Continue as indicated on the charts overleaf; the first giving the basic procedure and the other two the methods of checking the result.

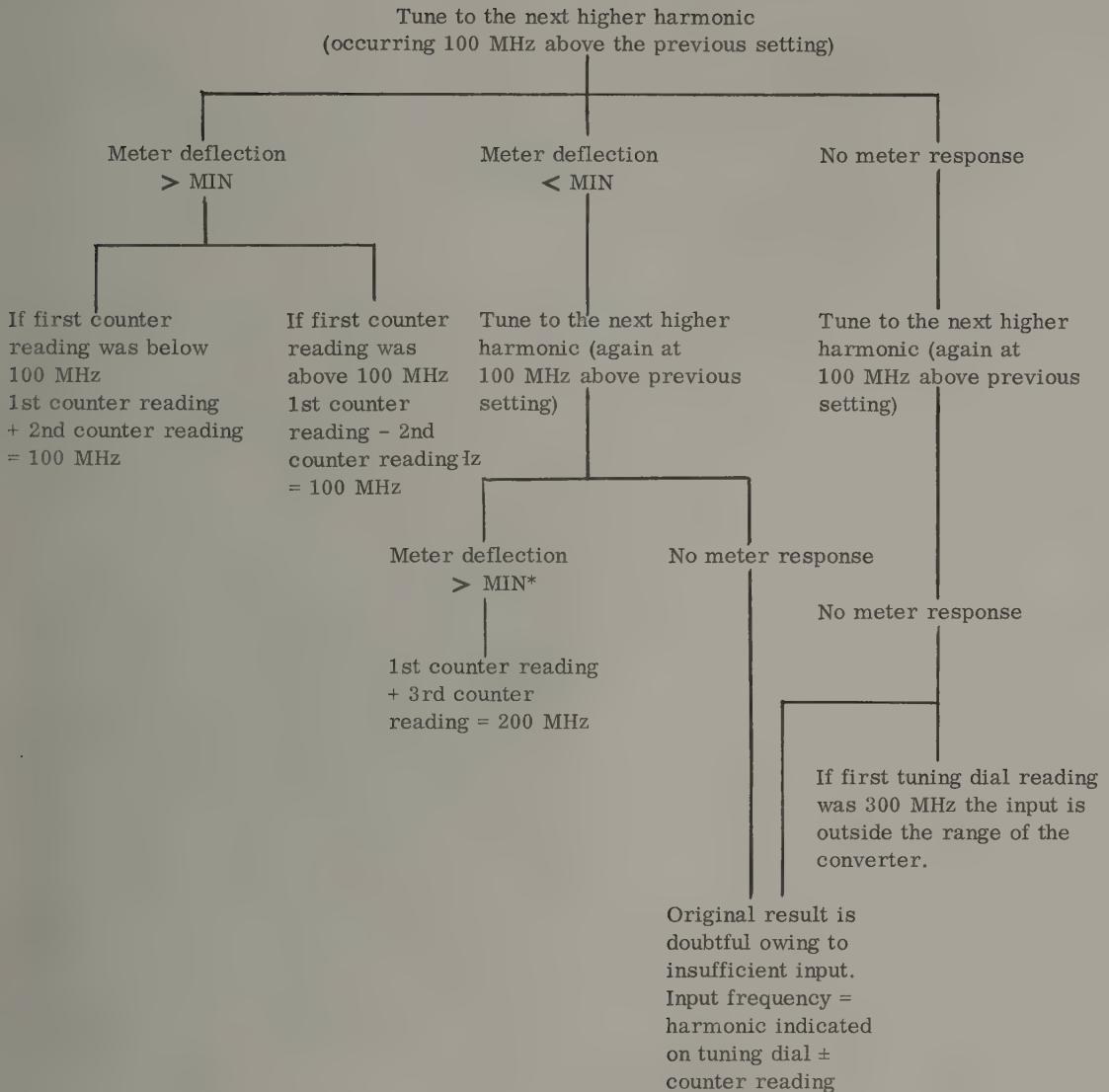
2.7 USE AS AN AMPLIFIER

For signals between 1 and 100 MHz which are of too low amplitude to trigger the counter normally, the TM 8094 may be used to amplify the signal. To do this apply the signal to INPUT B and set the FUNCTION switch to CONVERT B. (The setting of the tuning control has no effect in this application.) The counter is otherwise used as detailed in Section 2.5.



Basic operating instructions

CHECK 1



NOTES:

- 1)* This is caused by the difference between the input and the previous tuning setting being too small to give a correct counter reading.
- 2) At some frequencies a consistent counter reading may be obtained without the meter pointer reaching the MIN line. This reading may be considered valid but remember that there is no indication of whether the counter reading is added to or subtracted from the harmonic indicated on the Tuning dial.

CHECK 2

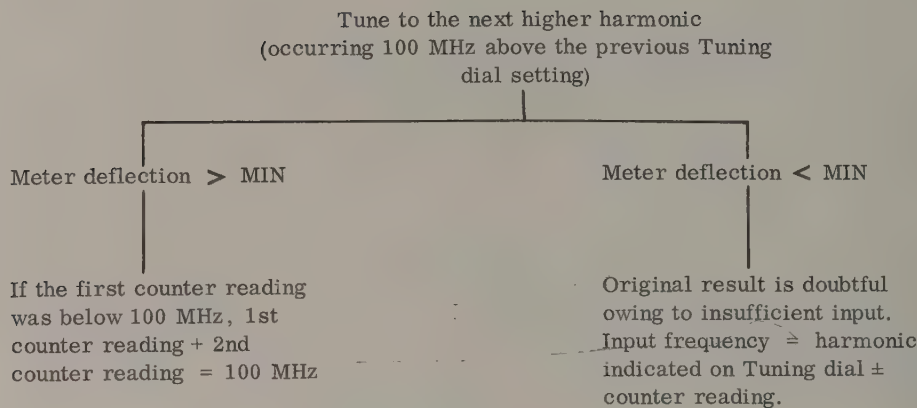


Table 2.1

Examples of typical measurements

Input frequency (GHz)	Mixing harmonic (GHz) (Tuning control reading)	Difference frequency (MHz) (Counter reading)	
0.717	0.7	17	} sum = 100
	0.8	83	
3.204	3.1	*104	} sum = 100
	3.2	4	
	3.3	96	
1.2008	1.1	100.8	} 1st & 3rd sum = 200
	1.2	* 0.8	
	1.3	99.2	

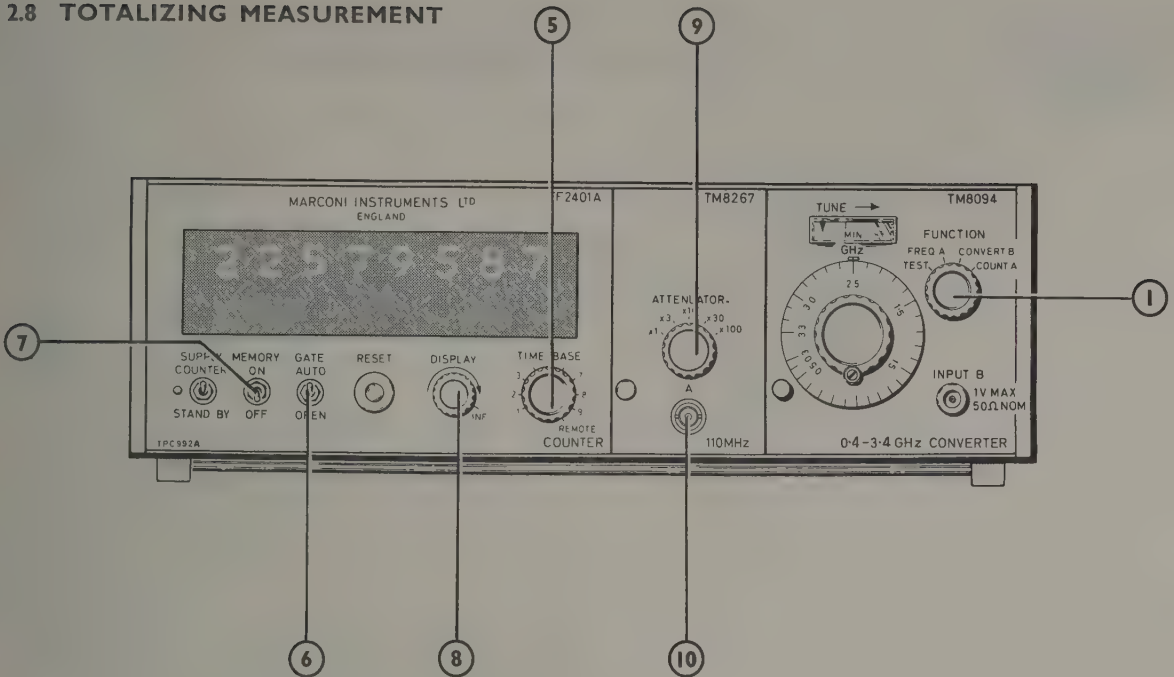
* Output may be insufficient to give correct counter reading

Once you have become familiarized with the basic operating techniques, Table 2.2. will be found useful as a quick guide to the use of the instrument when set for the CONVERT B function.

Table 2.2

Tuning control setting 1st	2nd	3rd	Input frequency	Check
ψ	ψ		1st setting + counter reading	1st reading ± 2nd reading = 100 MHz
ψ	low	ψ	1st setting + counter reading	1st reading + 3rd reading = 200 MHz
low	ψ	ψ	2nd setting + counter reading	2nd reading ± 3rd reading = 100 MHz
low	ψ	low	2nd setting ± counter reading	} No check. Result uncertain owing to insufficient input
ψ	low	-	1st setting ± counter reading	
ψ	-	-	If 1st setting is 300 MHz input is 300 MHz - counter reading	No check
ψ				= meter reading reached MIN line.
low				= meter reading does not reach MIN line.
-				= no meter response.

2.8 TOTALIZING MEASUREMENT



Functional description

With the FUNCTION switch in the COUNT A position the instrument totalizes the input. Fig. 2.5 shows a simplified functional diagram of the instrument in this operating mode. The input is applied to the A input connector. The decade counting units count the total number of cycles that occur while the gate signal is open. The gate is opened and closed manually by setting the GATE switch to OPEN and then to AUTO.

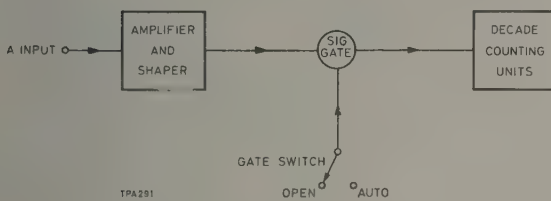


Fig. 2.5 Functional diagram for totalizing measurement

- ⑤ TIME BASE switch to the desired position.
- ⑥ GATE switch to AUTO.
- ⑦ MEMORY switch and DISPLAY control as desired.
- ⑧ A ATTENUATOR to maximum setting.
- ⑩ Apply the signal to be counted to the A Input connector and reduce the attenuator setting until the instrument counts satisfactorily.
- ① Set the FUNCTION switch to COUNT A.
- ② Set the GATE switch to OPEN to start totalizing.
- ③ Set the GATE switch to AUTO to stop totalizing.

CAUTION

Input must not exceed 100 V r. m. s. for 110 MHz Range unit.

Operating procedure

Set the controls as follows:

- ① FUNCTION switch to FREQ A.

After completion of the measurement, press the RESET button to erase the readout. The results of two or more measurements may be added by not pressing the RESET button after completion of each measurement.

Technical description

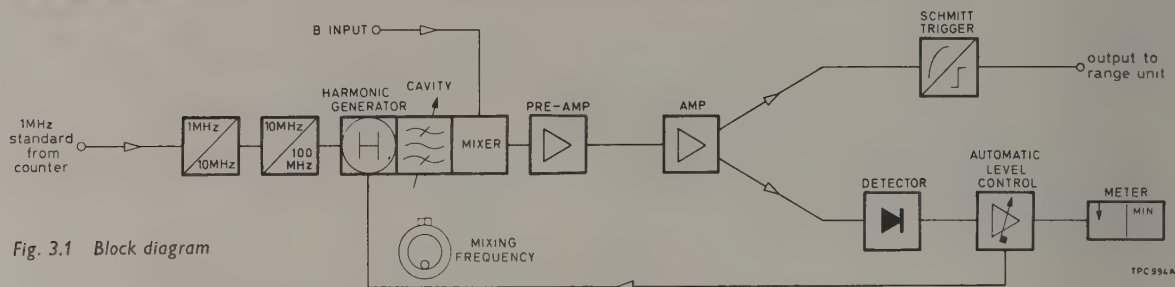


Fig. 3.1 Block diagram

3.1 CIRCUIT SUMMARY

Fig. 3.1 shows the block diagram for the unit. The 1 MHz standard, from the crystal oscillator, is multiplied to 100 MHz in two stages; the multiplier output has very low levels of sub-harmonic to avoid spurious responses in the main tuning. The 100 MHz signal drives a harmonic generator and the resulting harmonics are coupled into a resonant cavity which is tunable by a front panel control. This cavity acts as a pass band filter to select a given harmonic which is then mixed with the input to be measured. The resultant difference frequency is amplified and fed through to the Schmitt trigger. The output from the Schmitt trigger is buffered and fed to the auxiliary counter input.

3.2 1-10 MHz MULTIPLIER, TM 8504

Circuit diagram—Fig. 7.2

The 1 MHz standard is amplified in VT1 and VT2, and then applied to the x5 multiplier. This employs 5 MHz tuned circuits, residual 1 MHz being removed by C8 and L2 in the coupling to the x2 multiplier. The operation of this stage is similar to that of the x5 multiplier but 10 MHz tuned circuits are used.

The 10 MHz signal is shaped in transistors VT5 and VT6 and delivered at the output as a 6 V e.m.f. square wave.

3.3 10-100 MHz MULTIPLIER, TM 8506

Circuit diagram—Fig. 7.2

The 10 MHz signal from TM 8504 is applied to a x5 multiplier employing circuits similar to those in the 1 to 10 MHz multiplier. The signal is then applied to a x2 multiplier.

The residual sub-harmonic content in the 100 MHz waveform is further reduced by a tuned output amplifier; -VT3. The output is a sine wave of approximately 0.3 V r.m.s.

3.4 HARMONIC GENERATOR, TM 8593

Circuit diagram—Fig. 7.2

The harmonic generator comprises two printed circuit boards; a 100 MHz tuned amplifier (TM 8407) and the cavity input (TM 8590).

Harmonics of 100 MHz are generated by a step recovery diode. This device conducts normally when forward biased; when it is switched from forward conduction to reverse bias, reverse current flows initially then rapidly cuts-off, producing a waveform rich in harmonics (see Fig. 3.2).

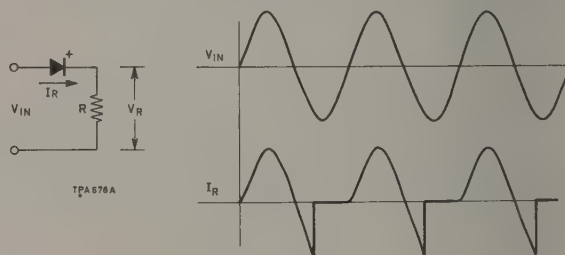


Fig. 3.2 Operation of step recovery diode

R1, in the cavity input loop, damps ringing caused by fast transients; the value of this resistor is partially determined by the amount of spurious 100 MHz in the difference frequency amplifier.

RV1 controls the level of signal in the cavity and is adjusted to give the best compromise between sensitivity and spurious 100 MHz pick-up.

To ensure that the maximum signal is injected into the cavity, the step recovery diode and the input loop are mounted on a double sided printed board which forms a capacitance across the cavity opening; this capacitance is C10 on TM 8590. Fig. 3.3 shows the construction of the input coupling.

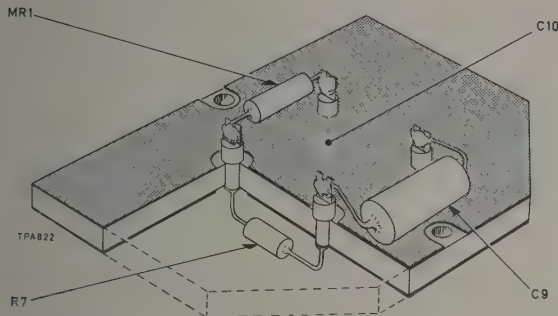


Fig. 3.3 Cavity input board

3.5 RESONANT CAVITY

Circuit diagram—Fig. 7.1

The cavity is basically a cylinder with a moveable piston. At high frequencies the piston is almost completely withdrawn and the cavity behaves as a resonant quarter wave line. At lower frequencies the cavity operates as an inductive length of coaxial line resonating with the capacitance between the piston and the cavity end wall. The piston is driven by the front panel tuning control which indicates the harmonic frequency that has been selected. The required harmonic of 100 MHz is selected by the cavity from the complete spectrum of harmonics generated in the previous stages.

3.6 MIXER AND PRE-AMPLIFIER, TM 9204

Circuit diagram—Fig. 7.1

The simple mixer circuit employs a single diode MR1, which is pre-biased with a small forward current. (A machined block contains the r. f. components mounted coaxially in order to reduce losses and improve the input impedance matching.) When the INPUT frequency is within approximately 100 MHz a difference frequency is generated and fed to the pre-amplifier.

Fig. 3.4 illustrates the position of the major components of the mixer and pre-amplifier.

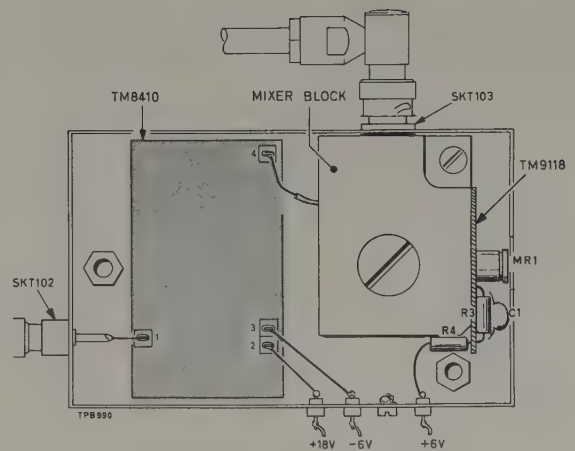


Fig. 3.4 Construction of mixer

The pre-amplifier TM 8410 is fitted to increase the stability of the amplifier, and to match the mixer to the main amplifier. A cascode stage containing transistors VT1, VT2 forms the pre-amplifier. An input choke L1 provides a low impedance path to signals of up to 100 MHz, but comparatively high impedance to frequencies above 300 MHz. The collector load is a toroidal transformer to match the collector impedance to the main amplifier input.

3.7 100 MHz WIDE BAND AMPLIFIER, TM 8408

Circuit diagram—Fig. 7.1

The amplifier has two cascode stages (of similar characteristics to the one in the pre-amplifier) plus one output stage. The total gain of the amplifier is approximately 200.

To make the frequency response substantially flat from 1 to 104 MHz the performance of each stage is peaked by capacitors in the emitter circuit. The two cascode stages are supplied from the +20V line.

The last stage of amplification provides two outputs:

1) A low impedance output is derived from a toroidally wound transformer T1, and is fed to the Schmitt trigger. R24 is fitted to reduce the effect on the meter deflection of the trigger operation.

2) The second output is detected in a peak-to-peak detector MR6/7, and used to drive the ALC and meter circuit.

3.8 AUTOMATIC LEVEL CONTROL, SCHMITT TRIGGER AND METER CIRCUIT, TM 8409

Circuit diagram—Fig. 7.1

Automatic level control

This circuit has two functions which are:

- 1) To prevent the Schmitt trigger being overloaded.
- 2) To provide the drive for the tuning meter.

The circuit concept is that the gain of a transistor is reduced by lowering the current and/or the voltage applied to it. The stage of amplification, described in Section 3.4 is designed so that, as the 18 V supply is reduced, the collector voltage falls thus reducing the gain of this control stage. The ALC circuit comprises a series stabilized power supply in which the reference voltage is replaced by the detected output of the wideband amplifier.

The detected output is buffered in transistor VT1 and then amplified by VT4 which controls a

regulator VT2. With no input VT2 is saturated due to the base current supplied through VT3. When the amplifier input rises the detector output to the base of VT1 rises and VT1, then VT4, conduct, reducing the regulator base current.

A point is reached when the current available for the base of VT2 is insufficient to maintain the level of the 18 V line. The supply voltage falls and so the amplifier gain decreases, and the circuit will stabilize with a defined output amplitude from the wide band amplifier controlled by R3, R4. R15 limits the current through VT 2 in the case of a short circuit on the 18V line.

Meter circuit

The tuning meter is required to give a clear tuning peak for a wide range of levels, which implies a non-linear relation between amplifier input and meter deflection. Until the ALC operates the current in VT1 rises with increasing amplifier input, increasing the voltage across RV1 and R2. When the ALC operates, the voltage across VT2 increases with increased input. The meter is connected to respond to the sum of the two. R9 and R13 compensate for the standing voltage that exists across VT2 and diode MR1 protects the meter from overloading.

Schmitt trigger

Transistors VT5 and VT6 form a conventional Schmitt trigger. The voltage levels are defined by Zener diode MR2 in the crossover network. Transistors VT7 and 8 are further shaping stages.

4.1 GENERAL

This chapter of the manual is intended as a general guide to the servicing of the unit. In case of difficulties which cannot be resolved with the aid of this book, please contact our Service Division at the address on the rear cover, or your nearest Marconi Instruments representative. Always mention the type number and serial number of your unit.

4.2 ACCESS TO CIRCUIT BOARDS

Note: If the maximum input is exceeded, the mixer diode may be damaged. This can be replaced by removing the mixer box lid and unplugging the diode.

The top cover of the unit is released by removing the screw located in the rear of the unit (at top centre); once this screw is removed, the cover can be taken off. Fig. 4.1 shows the boards etc., which are made available when the cover is removed.

To gain access to the mixer and pre-amplifier board remove the lid of the screened box on the base of the unit. Similarly to gain access to the harmonic generator, remove the lid of the screened box on the top side, see Fig. 4.1. All three boards may be removed by disconnecting the leads and, if appropriate, removing the facing nuts.

4.3 INSTRUMENT PERFORMANCE

General: The following sections cover the checking of the main points of performance of the unit. If it is found necessary to check the performance, it should be done in conjunction with a TF 2401 series counter and a range unit, both of which are working correctly. All adjustments should be made with the cover removed from the counter.

Limits: Limits are for guidance only and are not guaranteed performance specifications unless they are also quoted in the Data Summary.

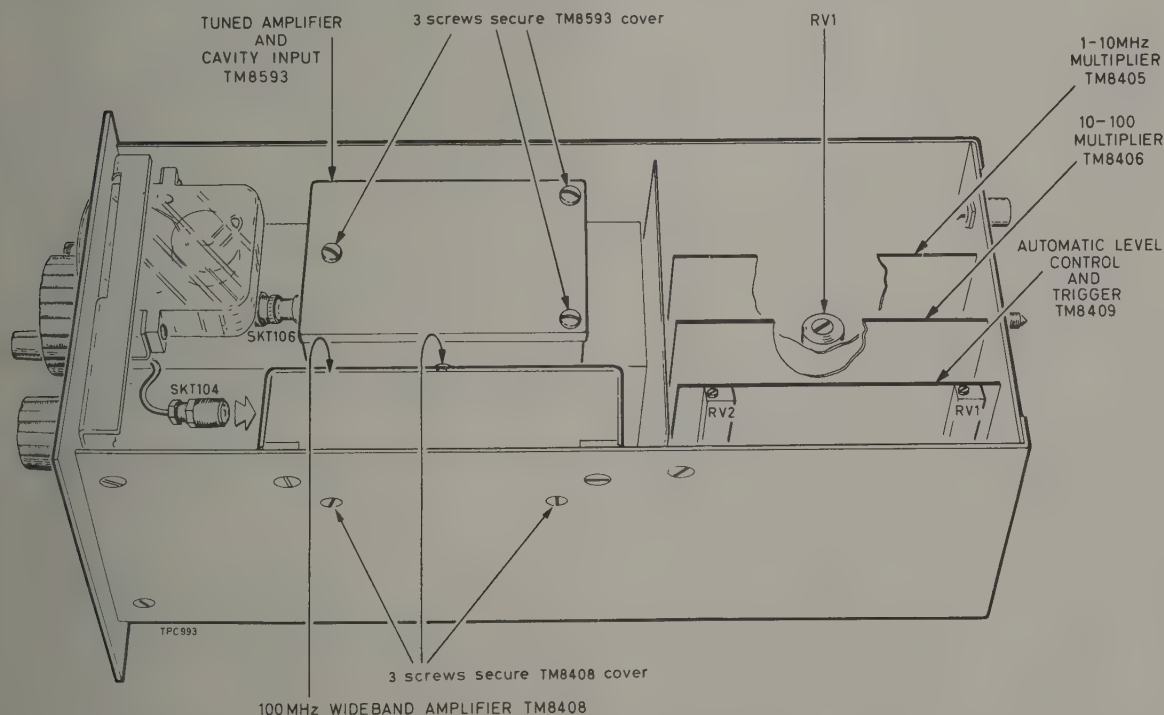


Fig. 4.1 Board positions

Test equipment required

- a) Oscilloscope; 100 MHz general purpose.
- b) Signal Generator (10 MHz - 410 MHz);
e.g. **mi** TF 801 Series.
- c) Signal Generator (450 MHz - 1200 MHz);
e.g. **mi** TF 1060 Series.
- d) R. F. Millivoltmeter; e.g. **mi** TF 2603.
- e) Coaxial 'T' Connector; e.g. **mi** TM 7948.
- f) 50 Ω Load; standardized at 100 MHz;
e.g. **mi** TM 7967.
- g) Ohmmeter; e.g. Avo, model 8.

4.4 SETTING UP THE 1-10 MHz MULTIPLIER, TM 8405

Apparatus: (a)

- 1) Trigger the oscilloscope from the 1 MHz standard from the BNC socket on the rear panel of the TF 2401 marked 'EXT/INT' (switched to 'INT').
- 2) Connect the oscilloscope input to pin 6 of TM 8405 and tune L1, L2, L3 and L4 for maximum output and minimum distortion. The output level should be of the order of 6 V peak-to-peak and the envelope distortion less than 50 mV peak-to-peak.

4.5 SETTING UP THE 10-100 MHz MULTIPLIER TM 8406 AND HARMONIC GENERATOR

Apparatus: (a)

- 1) Trigger the oscilloscope as in Section 4.4.1 and set RV1 on the chassis to maximum (fully clockwise).
- 2) Remove the cavity input box lid.
- 3) Connect the oscilloscope input to pin 4 of TM 8407 and tune C4 on TM 8407 first and then C4, 5, 11, 12, 18 on TM 8406 for maximum input and minimum distortion. The output level should be of the order of 0.3 V r.m.s. and envelope distortion should be less than 30 mV peak-to-peak.

4.6 TUNING THE CAVITY INPUT, TM 8590

Apparatus: (a)

- 1) Remove the cavity input lid and connect the oscilloscope to pin 4.

2) Tune C4 for the maximum indication, which should be about 2 V r.m.s.

- 3) Replace the cavity input lid.

4.7 TRIGGER LEVEL AND METER SETTING

Apparatus: (c)

- 1) Disconnect plug PL102 from the pre-amplifier TM 8410 and connect to the output from the signal generator. Adjust the signal generator output to be 5 mV at a frequency of 100 MHz.
- 2) Adjust the trigger level potentiometer RV2 on TM 8409 to give a stable count.
- 3) Repeat this process while decreasing the signal generator level until maximum sensitivity is reached.
- 4) Increase the generator output by 5 dB and, if necessary, adjust RV1 on TM 8409 to give a deflection on the MIN mark of the meter.
- 5) Disconnect the signal generator and reconnect plug PL102 to TM 8410.

4.8 MAXIMUM SPURIOUS SIGNAL

Apparatus: (a) and (c)

- 1) Set RV1 fully counter-clockwise.
- 2) Connect the oscilloscope probe to pin 18 of TM 8408. Using the front panel control, tune the cavity through its range and observe the maximum spurious signal. If this is more than 0.3 V peak-to-peak, adjust RV1 to give a maximum spurious signal not greater than 0.3 V peak-to-peak.
- 3) Connect the signal generator to the INPUT B socket and set to 400 MHz at a level of 100 mV e.m.f.
- 4) With the oscilloscope still connected as in (2), tune the TM 8094 to 0.3 GHz and reduce the input level until the counter stops counting with the GATE switch set to OPEN.
- 5) Check that the output signal level is approximately 1 V peak-to-peak.

4.9 INPUT IMPEDANCE

Apparatus: (b), (d), (e), (f) and (g)

1) Set the ohmmeter to the 100 Ω range and connect across the input of the TM 8094. The resistance measured should be between 40 and 60 Ω ; if not, check R1 and R2, 27 Ω and 22 Ω respectively, in the mixer.

2) Connect the output of the signal generator and the voltmeter probe to the 'T' connector and, at a frequency of 350 MHz, adjust the signal generator level to give a reading on the valve voltmeter of 25 mV.

3) Connect the converter input to the open end of the 'T' connector (as in Fig. 4.4) and note the voltmeter reading (call this reading 'V1').

4) Replace the converter with the standard 50 Ω load and note the new reading on the voltmeter (call this reading 'V2').

5) Calculate the value of the input impedance using the following formula:

$$Z_{in} = \frac{V1}{V2} \times \frac{(25 - V2)}{(25 - V1)} \times 50$$

The result should be between 25 and 75 Ω .

Logic tables

5.1 INTRODUCTION

The following tables are relevant to the instrument as a whole, i.e., with a range unit and this function unit fitted.

Table 5.1 defines the select signals. The select signals are gating signals (see logic diagram in the range unit manual) which are generated by the FUNCTION switch on this unit.

Table 5.1
SELECT SIGNAL SYMBOLS

Select symbol	Label on front panel	Description
S1	A AMPLIFIER SEL	Selects input of A amplifier to be counted.
S4	TIME BASE CONTROL SEL	Selects output of time base to open and close count gate.
S8	REF FREQ TIME BASE INPUT SEL	Selects REF FREQ input to time base.
$\overline{S9}$	MULT PER MODE TIME BASE OUT SEL	Prevents selection of output of B amplifier as input to time base, and prevents selection of output appropriate for MULT PER mode.
S10	AUX INPUT SEL	Selects output of B amplifier to be counted.
$\overline{S12}$	PER MODE TIME BASE OUT SEL	Prevents selection of time base output appropriate for PER mode.
S13	10 MHz (or 100 MHz) SIGNAL SEL	Selects signal to be counted; 100 MHz for TM 8267.

Table 5.2 defines the function symbols: i.e. each function switch position is given a reference (F1, F2, etc.).

Table 5.2
FUNCTIONS

Function switch position symbol	Label on front panel	Description
F4	TEST	Self check
F5 (1)	FREQ A	Frequency measurement (within range unit limits)
F5 (2)	CONVERT B	Frequency measurement 0.3 - 3.3 GHz
F9	COUNT A	Totalizing measurement

Table 5.3 shows the selected signals that are active for any given position of the FUNCTION switch, and will be found useful when fault finding. For a given FUNCTION switch position the active select signals can be traced round the counter system; this is shown in the system logic diagram in the range unit manual.

Table 5.3
LOGIC SIGNAL CHART
(Function v. select signal)

	S1	S4	S8	$\overline{S9}$	S10	$\overline{S12}$	S13
F4		x	x	x		x	x
F5 (1)	x	x	x	x		x	
F5 (2)		x	x	x	x	x	

F9 x

Note: x = -6 V

Replaceable parts

Introduction

The frequency converter consists of a number of sub-assemblies, each of which is allocated an identity number in the sequence A0 to A6 inclusive as follows:-

- A0 - Main chassis
- A1 - A.L.C. and trigger
- A2 - 100 MHz wideband amplifier
- A3 - Pre-amplifier and mixer
- A4 - Cavity input and amplifier
- A5 - 10 - 100 MHz multiplier
- A6 - 1 - 10 MHz multiplier

The complete reference of a part consists of the sub-assembly number followed by its circuit reference, e.g., A4C5, A7R4, etc., and this should always be stated on any order, letter, etc. For convenience in the text and on circuit diagrams, the circuit reference is abbreviated by dropping the sub-assembly prefix except where there is risk of ambiguity.

Replaceable parts are grouped in order of sub-assembly designation and itemized in alphabetical order of circuit references, with miscellaneous parts at the end of each list. The following abbreviations are used:-

- C : capacitor
- Carb : carbon
- Cer : ceramic
- CRT : cathode ray tube
- Elec : electrolytic
- FS : fuse
- ILP : illumination lamp
- JK : jack
- L : inductor
- Log : logarithmic law
- M : meter
- Met : metal
- Min : minimum value
- MR : semiconductor diode
- Ox : oxide
- PL : plug
- Plas : plastic
- PLP : pilot lamp
- R : resistor
- RV : variable resistor
- S : switch
- SKT : socket
- T : transformer
- TE : total excursion
- TH : thermistor
- TP : terminal
- V : valve
- Var : variable or preset
- VT : transistor

- WW : wirewound
- X : ferrite bead
- † : value selected during test; nominal value listed
- ⌚ : feed-through component
- W : watts at 70 °C
- W* : watts at 55 °C
- W** : watts at 40 °C
- W*** : watts at 20 °C
- W^o : watts at unspecified temperature

All % tolerances are ± except where otherwise stated.

Ordering

When ordering replacement or spare parts, address the order to our Service Division (for address see rear cover) or nearest representative. Please specify the following information for each part required.

- (1) Type and serial number of instrument (see rear data plate).
- (2) Complete circuit reference (see Introduction).
- (3) Description.
- (4) M.I. code number.

If a part is not listed, state its function, location and description when ordering.

Semiconductor types

The M.I. code listed against each diode or transistor refers, generally, to more than one type of semiconductor. These types are listed below against the M.I. code number.

M.I. code numbers that start with a 4 are components which are specially selected to our own specifications.

DIODES

28331-355:
28357-548: 1S44

TRANSISTORS

28335-671: MA4755, hpa0112
28424-747: ACY20
28451-692: 2N3663
28452-192: BSY38
28552-197: BSX20, 2N2369
28453-828: 2N3707
28453-856: MM1941
28454-776: MM1613

A0 - Main chassis

When ordering, prefix circuit reference with A0

Circuit reference	Description	M.I. code
C1	Cer 0.1μF +50-20% 30V	26383-110
C2	Cer 0.1μF +50-20% 30V	26383-110
C3	Plas 100pF ±2pF 125V	26516-241
C4	Cer 0.1μF +50-25% 30V	26383-110
C5	Cer 0.1μF +50-25% 30V	26383-110
M201	1mA F.S.D.	44576-110
PL101	50 way	23435-421
PL102	Min. Coaxial	23441-014
PL103	Coaxial	23444-053
PL106	Coaxial	23441-014
PL132	Coaxial	23443-020
R1	Carb 2.2kΩ 10% 1/10W	24341-288
RV1	Carb 4.7kΩ 20% ¼W	25611-122
S209	4 pos.	44323-505
SKT104	TB 43582	43123-033
SKT161	18 way	23010-018
SKT162	18 way	23010-018
SKT163	18 way	23010-018
SKT164	18 way	23010-018
SKT202	Coaxial	23443-779

A1 - A.L.C. and Trigger

When ordering, prefix circuit reference with A1

C1	Elec 1μF +100-20% 50V	26414-106
C2	Elec 1μF +100-20% 50V	26414-106
C3	Elec 10μF +50-20% 35V	26414-121
C4	Cer 0.1μF +50-20% 30V	26383-031
C5	Cer 0.1μF +50-20% 30V	26383-031
C6	Cer 0.01μF +80-20% 100V	26383-055
C7	Cer 0.1μF +50-20% 30V	26383-031

When ordering, prefix circuit reference with A1

Circuit reference	Description	M.I. code
C8	Cer 0.1μF +50-20% 30V	26383-031
C9	Cer 22pF ±0.25pF 750V	26324-715
C10	Cer 0.1μF +50-20% 30V	26383-031
C11	Cer 22pF ±0.25pF 750V	26324-715
C12	Cer 33pF ±5% 750V	26324-822
L1	Ferrite bead	23635-833
L2	Inductor	44225-211
L3	Inductor	44225-211
MR1	Signal/switching diffused	28357-548
MR2	Zener diode 4.3V	28371-381
MR3	Zener diode 3.9V	28371-243
MR4	Signal diode	28331-355
MR5	Signal diode	28331-355
R1	Carb 68kΩ 10% 1/10W	24341-331
R2	Carb 470Ω 10% 1/10W	24341-269
R3	Met ox 560Ω 5% ¼W	24581-234
R4	Met ox 120Ω 5% ¼W	24581-218
R5	Carb 560Ω 10% 1/10W	24341-272
R6	Met ox 3.3kΩ 5% ¼W	24581-252
R7	Carb 2.2kΩ 10% 1/10W	24341-288
R8	Met ox 4.7kΩ 5% ¼W	24581-256
R9	Carb 1kΩ 10% 1/10W	24341-280
R10	Carb 100Ω 10% 1/10W	24341-250
R11	Carb 330Ω 10% ½W	24342-063
R13	Carb 18kΩ 10% 1/10W	24341-316
R14	Carb 820Ω 10% 1/10W	24341-278
R15	Carb 15Ω 10% 1/10W	24341-224
R16	Carb 5.6kΩ 10% 1/10W	24341-303
R17	Carb 22kΩ 10% 1/10W	24341-318
R18	Met ox 390Ω 5% ¼W	24581-230
R19	Carb 150Ω 10% 1/10W	24341-254
R20	Carb 22Ω 10% ½W	24342-028
R21	Carb 160Ω 7% TE ⅜W	24552-055
R22	Carb 2.2kΩ 10% 1/10W	24341-288
R23	Carb 820Ω 10% 1/10W	24341-278
R24	Carb 150Ω 10% ½W	24342-054

For symbols and abbreviations see introduction to this chapter

When ordering, prefix circuit reference with A1

Circuit reference	Description	M.I. code
R25	Carb 100Ω 10% 1/10W	24341-250
R26	Carb 4.7kΩ 10% 1/10W	24341-300
R27	Carb 100Ω 10% 1/10W	24341-250
RV1	WW 500Ω 10% $\frac{1}{2}$ W	25886-611
RV2	WW 500Ω 10% $\frac{1}{2}$ W	25886-611
VT1	Low noise	28453-828
VT2	Special	44522-018
VT3	40V p.n.p.	28424-747
VT4	Special	44522-018
VT5	Special	44522-017
VT6	Special	44522-017
VT7	Special	44522-030
VT8	Silicon planar, epitaxial	28451-692

A2 - 100 MHz wideband amplifier

When ordering, prefix circuit reference with A2

C1	Cer 0.01μF +80-20% 100V	26383-055
C2	Cer 0.1μF +50-25% 30V	26383-031
C3	Cer 0.01μF +80-20% 100V	26383-055
C4	Cer 0.1μF +50-25% 30V	26383-031
C5	Plas 370pF 5% 350V	26516-385
C6	Plas 82pF ±2pF 125V	26516-222
C7	Cer 0.1μF +50-25% 30V	26383-031
C8	Cer 0.1μF +50-25% 30V	26383-031
C9	Cer 0.01μF +80-20% 100V	26383-055
C10	Cer 0.1μF +50-25% 30V	26383-031
C11	Cer 0.1μF +50-25% 30V	26383-031
C12	Cer 0.1μF +50-25% 30V	26383-031
C13	Plas 370pF 5% 350V	26516-385
C14	Plas 120pF 2% 125V	26516-262
C15	Cer 0.1μF +50-25% 30V	26383-031
C16	Cer 0.1μF +50-25% 30V	26383-031
C17	Plas 370pF 5% 350V	26516-385
C18	Cer 0.01μF +80-20% 100V	26383-055
C19	Plas 68pF ±2pF 125V	26516-201
C20	Cer 0.01μF +80-20% 100V	26383-055

When ordering, prefix circuit reference with A2

Circuit reference	Description	M.I. code
C21	Cer 0.1μF +50-25% 30V	26383-031
C22	Cer 0.1μF +50-25% 30V	26383-031
C23	Cer 0.1μF +50-25% 30V	26383-031
L1	1μH	23635-833
L2	100μH	44231-121
MR1	Signal/switching, diffused	28357-548
MR2	Signal/switching, diffused	28357-548
MR3	Signal/switching, diffused	28357-548
MR4	Special	44521-012
MR5	Special	44521-010
MR6	Special	44521-010
MR7	Special	44521-012
PL104	Coaxial	23443-030
R1	Carb 22Ω 10% 1/10W	24341-228
R2	Carb 47Ω 10% 1/10W	24341-237
R3	Carb 1kΩ 10% 1/10W	24341-280
R4	Carb 1.8kΩ 10% 1/10W	24341-286
R5	Carb 2.7kΩ 10% 1/10W	24341-292
R6	Carb 1.5kΩ 10% 1/10W	24341-284
R7	Carb 22Ω 10% 1/10W	24341-228
R8	Carb 470Ω 10% 1/10W	24341-269
R9	Carb 18Ω 10% 1/10W	24341-226
R10	Met ox 22Ω 5% $\frac{1}{4}$ W	24581-203
R11	Carb 47Ω 10% 1/10W	24341-237
R12	Carb 1kΩ 10% 1/10W	24341-280
R13	Carb 1.8kΩ 10% 1/10W	24341-286
R14	Carb 2.7kΩ 10% 1/10W	24341-292
R15	Carb 1.5kΩ 10% 1/10W	24341-284
R16	Carb 470Ω 10% 1/10W	24341-269
R17	Carb 18Ω 10% 1/10W	24341-226
R18	Met ox 22Ω 5% $\frac{1}{4}$ W	24581-203
R19	Carb 3.3kΩ 10% 1/10W	24341-294
R20	Carb 2.7kΩ 10% 1/10W	24341-292
R21	Carb 680Ω 10% $\frac{1}{2}$ W	24342-076

For symbols and abbreviations see introduction to this chapter

When ordering, prefix circuit reference with A2

Circuit reference	Description	M.I. code
R22	Carb 18Ω 10% 1/10W	24341-226
R23	Met ox 22Ω 5% $\frac{1}{2}$ W	24581-203
R24	Carb 22Ω 10% 1/10W	24341-228
R25	Carb 560Ω 10% 1/10W	24341-272
T1	TM 8443	44225-207
T2	TM 8443	44225-207
VT1	h.f. epitaxial	28453-856
VT2	General purpose	28452-197
VT3	h.f. epitaxial	28453-856
VT4	General purpose	28452-197
VT5	h.f. epitaxial	28453-856

When ordering, prefix circuit reference with A3

R8	Carb 47Ω 10% 1/10W	24341-237
R9	Carb 2.7kΩ 10% 1/10W	24341-292
R10	Carb 1.5kΩ 10% 1/10W	24341-284
R11	Carb 330Ω 10% 1/10W	24341-263
R12	Met ox 27Ω 5% $\frac{1}{2}$ W	24581-205
R13	Met ox 56Ω 5% $\frac{1}{2}$ W	24581-210
SKT102	MIP 44601	23441-044
SKT103	MIP 44491	23444-193
T1	TM 8443	44225-207
VT1	h.f. epitaxial	28453-856
VT2	General purpose	28452-197

A3 - Pre-amplifier and mixer

When ordering, prefix circuit reference with A3

C1	Cer 0.01μF +80-20% 100V	26383-055
C6	Cer 0.01μF +80-20% 100V	26383-055
C7	Cer 0.01μF +80-20% 100V	26383-055
C9	Cer 0.01μF +80-20% 100V	26383-055
C10	Cer 0.01μF +80-20% 100V	26383-055
C11	Cer 33pF 5% 750V	26324-822
C12	Plas 82pF 2% 350V	26516-225
L1	TB 43593/4	35124-416
MR1	Special	44521-026
MR3	Signal/switching, diffused	28357-548
R1	Carb 27Ω 10% 1/10W	24341-231
R2	Carb 22Ω 10% 1/10W	24341-228
R3	Carb 15kΩ 10% 1/10W	24341-314
R4	Carb 15kΩ 10% 1/10W	24341-314
R5	Carb 47Ω 10% 1/10W	24341-237
R6	Carb 1kΩ 10% 1/10W	24341-280
R7	Carb 1.8kΩ 10% 1/10W	24341-286

A4 - Cavity input and amplifier

When ordering, prefix circuit reference with A4

C1	Cer 0.001μF +40-20% 500V	26383-242
C2	Cer 0.001μF +40-20% 500V	26383-242
C3	Cer 0.1μF +50-25% 30V	26383-031
C4	Air 2.5-13.4pF 750V	26817-238
C5	Cer 4.7pF ±0.25pF 750V	26324-017
C6	Cer 0.1μF +50-25 % 30V	26383-031
C7	Cer 0.001μF +40-20% 500V	26383-242
C8	Cer 0.1μF +50-25% 30V	26383-031
C9	Cer 22pF ±0.25pF 750V	26324-715
C10	30pF (Fabricated)	
C11	Cer 0.1μF +50-25% 30V	26383-031
C12	Cer 0.1μF +50-25% 30V	26383-031
L1	TM 8443/1	44231-121
L2	TB 43593/7	35124-414
MR1	Step recovery diode	28335-671

For symbols and abbreviations see introductions to this chapter

When ordering, prefix circuit reference with A4

Circuit reference	Description	M.I. code
R1	Carb 1k Ω 10% 1/10W	24341-280
R2	Carb 2.2k Ω 10% 1/10W	24341-288
R3	Carb 100 Ω 10% 1/10W	24341-250
R5	Carb 220 Ω 10% 1/10W	24341-258
R6	Carb 470 Ω 10% 1/10W	24341-269
R7	Carb 33 Ω 10% 1/10W	24341-233
R8	Carb 470 Ω 10% 1/10W	24341-269
R9	† Carb 47 Ω 10% 1/10W	24341-237
SKT106	MIP 44601	23441-044
VT1	General purpose	28452-197
VT2	200MHz 800mW	28454-776

A5 - 10-100 MHz multiplier

When ordering, prefix circuit reference with A5

C1	Plas 200pF $\pm$ 2% 500V	26516-320
C2	Cer 0.1 μ F +50-25% 30V	26383-031
C3	Cer 0.1 μ F +50-25% 30V	26383-031
C4	Cer 3-20pF	26845-147
C5	Plas 51pF $\pm$ 2pF 125V	26516-174
C6	Cer 2.2pF $\pm$ 0.25pF 750V	26324-011
C7	Plas 51pF $\pm$ 2pF 125V	26516-174
C8	Cer 3-20pF	26845-147
C9	Cer 0.1 μ F +50-25% 30V	26383-031
C10	Cer 0.1 μ F +50-25% 30V	26383-031
C11	Cer 1.5-10pF	26845-145
C12	Plas 10pF $\pm$ 1pF 350V	26516-010
C13	Cer 2.2pF $\pm$ 0.25pF 750V	26324-011
C14	Plas 10pF $\pm$ 1pF 350V	26516-010
C15	Cer 1.5-10pF	26845-145
C16	Plas 10pF $\pm$ 1pF 350V	26516-010
C17	Cer 0.1 μ F +50-25% 30V	26383-031
C18	Cer 1.5-10pF	26845-145
C19	Plas 15pF $\pm$ 1pF 350V	26516-019
C20	Cer 0.1 μ F +50-25% 30V	26383-031

When ordering, prefix circuit reference with A5

Circuit reference	Description	M.I. code
L1	TB 43593'	35124-412
L2	TB 43593	35124-412
L3	TB 43593/1	35124-413
L4	TB 43593/1	35124-413
L5	TB 43593/2	35124-417
L6	TB 43593/3	35124-128
MR1	Signal/switching, diffused	28357-548
MR2	Signal/switching, diffused	28357-548
MR3	Signal/switching, diffused	28357-548

R1	Carb 1k Ω 10% 1/10W	24341-280
R2	Carb 100 Ω 10% 1/10W	24341-250
R3	Carb 22 Ω 10% 1/10W	24341-228
R4	Carb 1k Ω 10% 1/10W	24341-280
R5	Carb 22 Ω 10% 1/10W	24341-228
R6	Carb 100 Ω 10% 1/10W	24341-250
R7	Carb 22 Ω 10% 1/10W	24341-228
R8	Carb 470 Ω 10% 1/10W	24341-269

VT1	General purpose	28452-192
VT2	Special	44522-017
VT3	Special	44522-017

A6 - 1-10 MHz multiplier

When ordering, prefix circuit reference with A6

C1	Plas 150pF $\pm$ 2% 125V	26516-287
C2	Cer 0.1 μ F +50%-25% 25V	26383-031
C3	Cer 0.1 μ F +50%-25% 25V	26383-031
C4	Plas 470pF $\pm$ 2% 125V	26516-400
C5	Plas 150pF $\pm$ 2% 125V	26516-287
C6	Cer 0.1 μ F +50%-25% 25V	26383-031
C7	Cer 0.1 μ F +50%-25% 25V	26383-031
C8	Plas 200pF $\pm$ 2% 125V	26516-315
C9	Cer 2.2pF $\pm$ 0.5pF 750V	26324-042

For symbols and abbreviations see introduction to this chapter

When ordering, prefix circuit reference with A6

Circuit reference	Description	M.I. code
C10	Plas 200pF $\pm 2\%$ 125V	26516-315
C11	Plas 51pF $\pm 2\text{pF}$ 125V	26516-174
C12	Cer 0.1 μ F +50%-25% 25V	26383-031
C13	Cer 0.1 μ F +50%-25% 25V	26383-031
C14	Plas 68pF $\pm 2\text{pF}$ 500V	26516-201
C15	Cer 2.2pF $\pm 0.5\text{pF}$ 750V	26324-042
C16	Plas 68pF $\pm 2\text{pF}$ 500V	26516-201
C17	Plas 51pF $\pm 2\text{pF}$ 125V	26516-174
C18	Cer 0.1 μ F +50%-25% 25V	26383-031
C19	Cer 0.1 μ F +50%-25% 25V	26383-031
C20	Plas 51pF $\pm 2\text{pF}$ 125V	26516-174
C21	Cer 0.01 μ F +80%-20% 100V	26383-055
L1	5 - 7.5 μ H	44254-204
L2	5 - 7.5 μ H	44254-203
L3	3 - 5 μ H	44255-204
L4	3 - 5 μ H	44244-203
MR1	Signal/switching, diffused	28357-548
MR2	Signal/switching, diffused	28357-548
MR3	Signal/switching, diffused	28357-548
MR4	Signal/switching, diffused	28357-548
MR5	Signal/switching, diffused	28357-548
R1	Carb 6.8k Ω $\pm 10\%$ 1/10W	24341-306
R2	Carb 1.5k Ω $\pm 10\%$ 1/10W	24341-284

When ordering, prefix circuit reference with A6

Circuit reference	Description	M.I. code
R3	Carb 470 Ω $\pm 10\%$ 1/10W	24341-269
R4	Carb 68 Ω $\pm 10\%$ 1/10W	24341-243
R5	Carb 47k Ω $\pm 10\%$ 1/10W	24341-326
R6	Carb 22 Ω $\pm 10\%$ 1/10W	24341-228
R7	Carb 470 Ω $\pm 10\%$ 1/10W	24341-269
R8	Carb 10 Ω $\pm 10\%$ 1/10W	24341-220
R9	Carb 1k Ω $\pm 10\%$ 1/10W	24341-280
R10	Carb 100 Ω $\pm 10\%$ 1/10W	24341-250
R11	Carb 22 Ω $\pm 10\%$ 1/10W	24341-228
R12	Carb 1k Ω $\pm 10\%$ 1/10W	24341-280
R13	Carb 100 Ω $\pm 10\%$ 1/10W	24341-250
R14	Carb 22 Ω $\pm 10\%$ 1/10W	24341-228
R15	Carb 6.8k Ω $\pm 10\%$ 1/10W	24341-306
R16	Carb 1.5k Ω $\pm 10\%$ 1/10W	24341-284
R17	Carb 470 Ω $\pm 10\%$ 1/10W	24341-269
R18	Carb 68 Ω $\pm 10\%$ 1/10W	24341-243
R19	Carb 47k Ω $\pm 10\%$ 1/10W	24341-326
R20	Carb 22 Ω $\pm 10\%$ 1/10W	24341-228
R21	Carb 470 Ω $\pm 10\%$ 1/10W	24341-269
VT1	General purpose	28452-192
VT2	General purpose	28452-192
VT3	General purpose	28452-192
VT4	General purpose	28452-192
VT5	General purpose	28452-192
VT6	General purpose	28452-192

For symbols and abbreviations see introduction to this chapter

Circuit diagrams

Circuit notes

1. ARRANGEMENT

The inter-unit wiring diagram, Fig. 7.3, shows all sub-assembly units in the equipment together with their reference designators (A1, A2, etc.) and type numbers (prefixed TM). Components that are not on a sub-assembly are part of the main chassis assembly (designated A0).

2. COMPONENT VALUES

Resistors: No suffix = ohms, k = kilohms, M = megohms.

Capacitors: No suffix = microfarads, p = picofarads.

Inductors: No suffix = henries, m = millihenries, μ = microhenries.

† value selected during test, nominal value shown.

3. VOLTAGES

Printed in *italics*. Voltages are d.c. and relative to chassis unless otherwise indicated. Measured with a 20 k Ω /V meter.

→ arrow indicates voltage source point.

4. SYMBOLS

➔ arrow indicates clockwise rotation of knob.

⦿ preset component.

FUNCTION panel marking.

2 printed board tag number.

○ other tag.

printed board edge connector.

5. SWITCHES

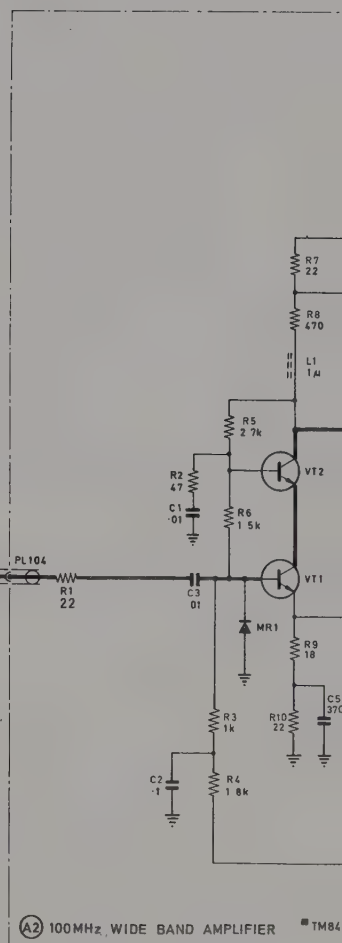
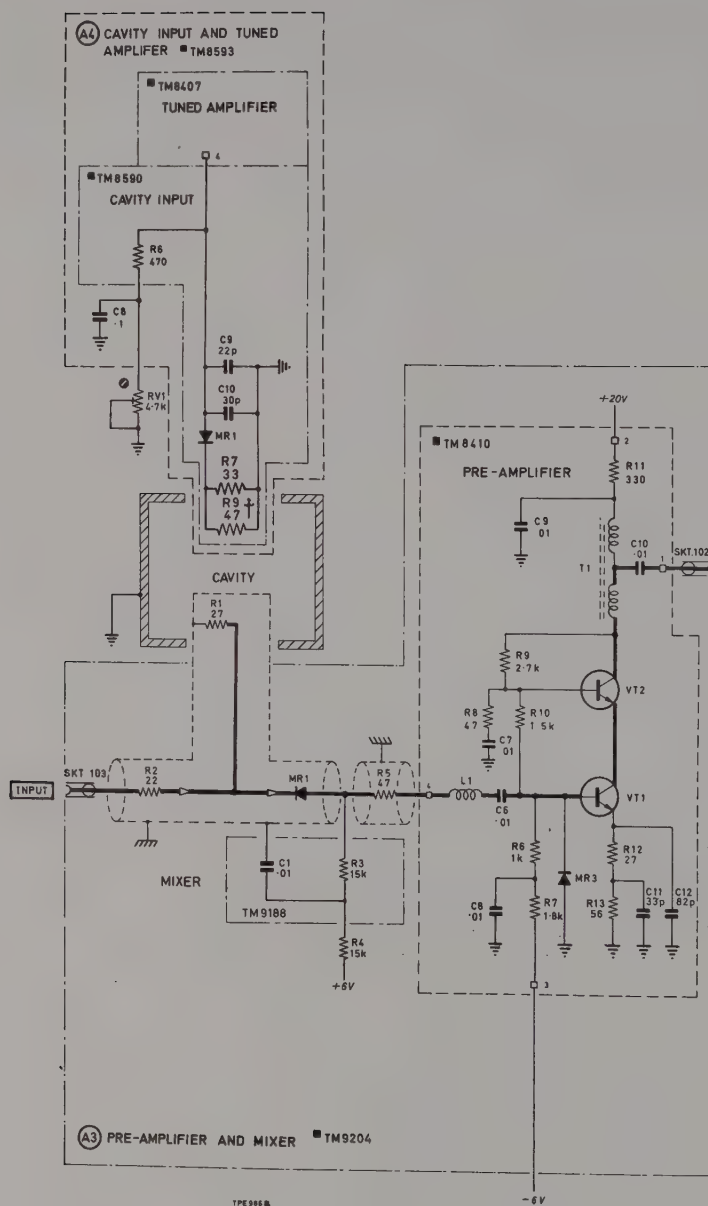
Rotary switches are drawn schematically. Numbers of letters indicate control knob setting as shown in the key diagrams. Sequence of sections reading from control knob end is as follows:

1F = 1st section, front

1B = 1st section, back

2F = 2nd section, front

etc.



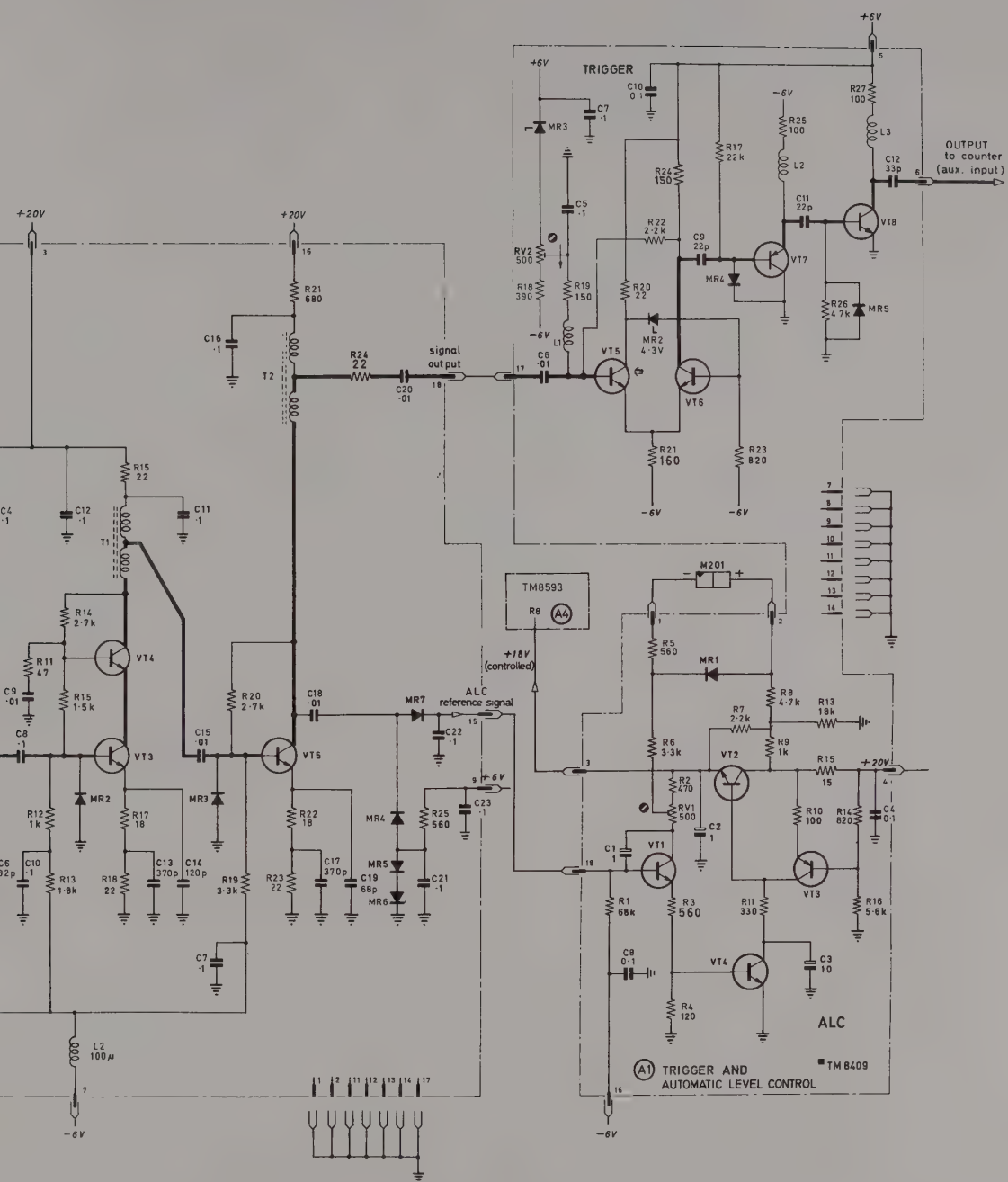
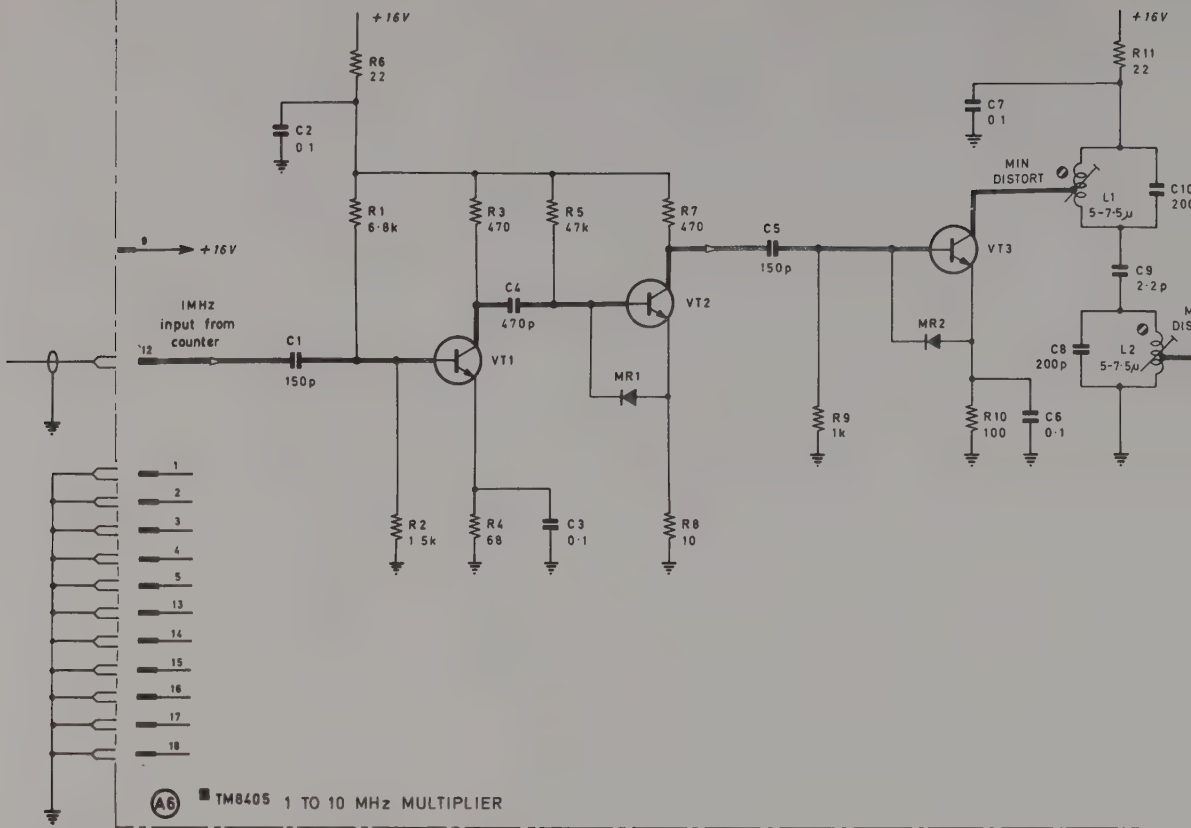


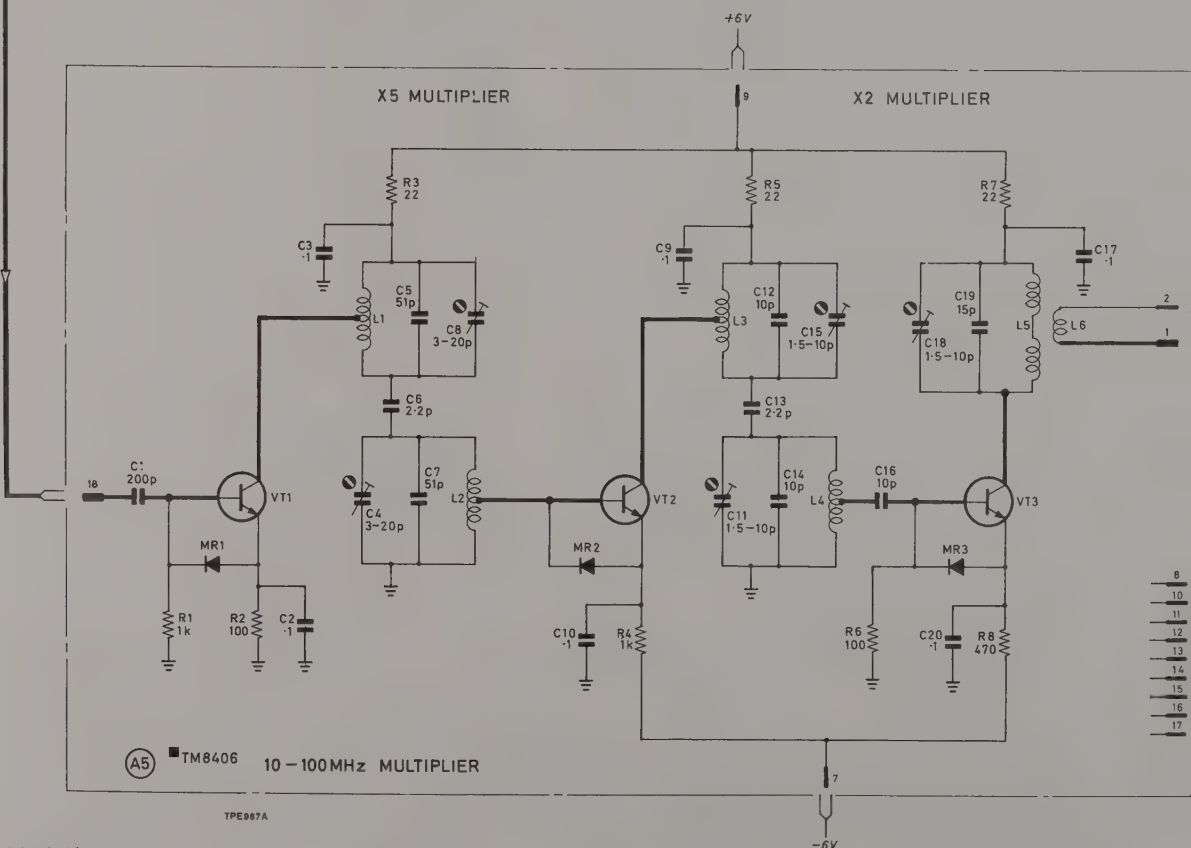
Fig. 7.1 Input and meter circuitry, A1, A2, A3 and A4

X5 MULTIPLIER



X5 MULTIPLIER

X2 MULTIPLIER



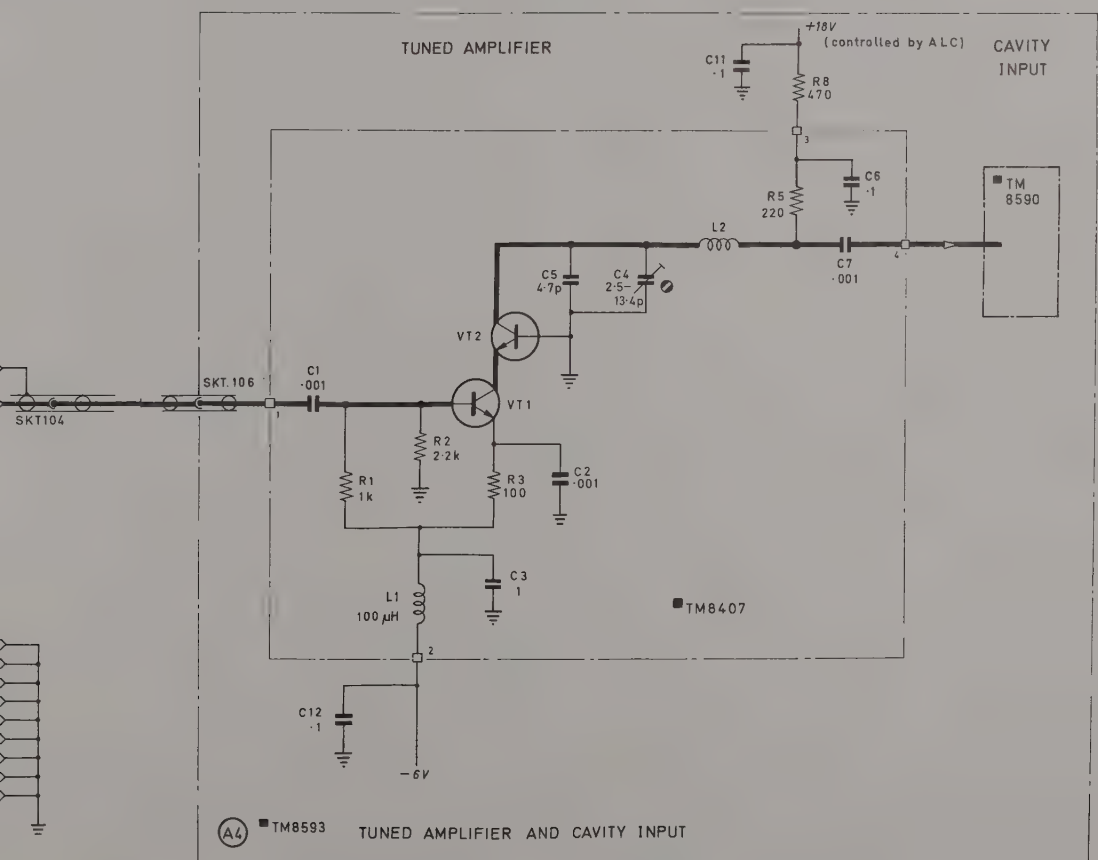
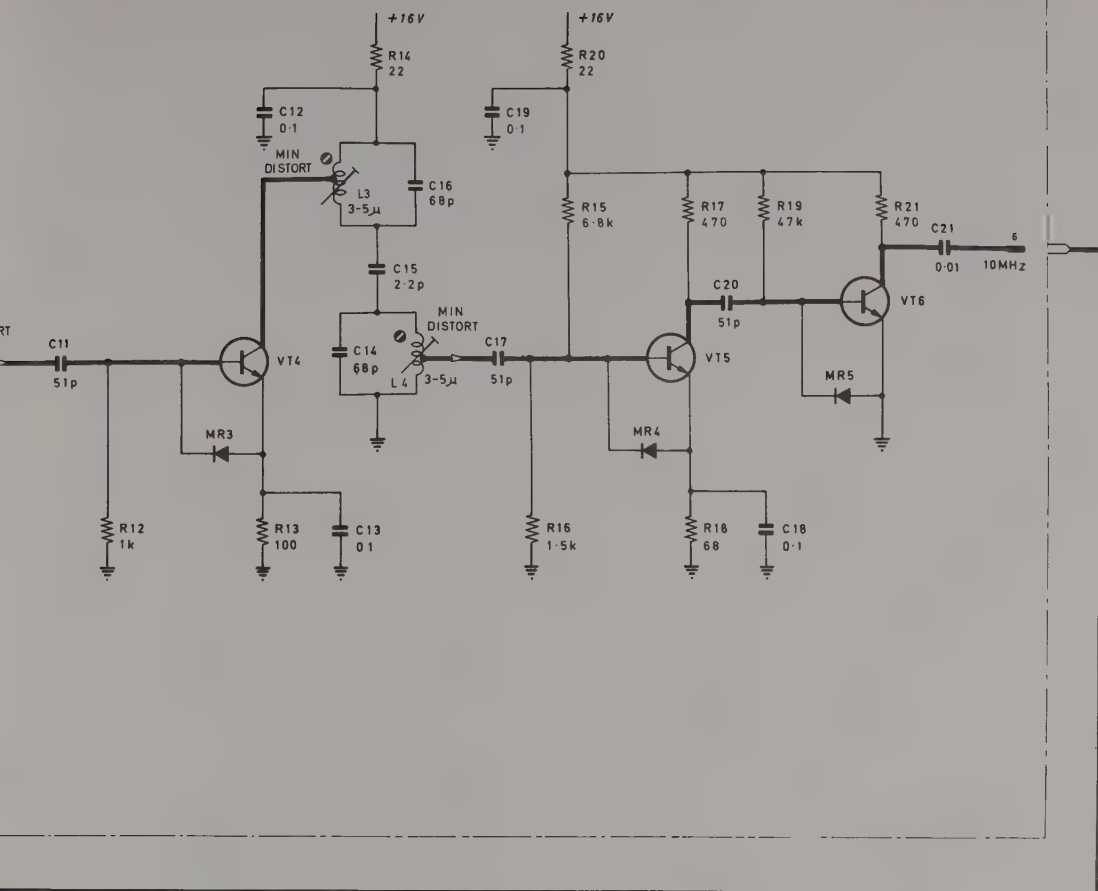
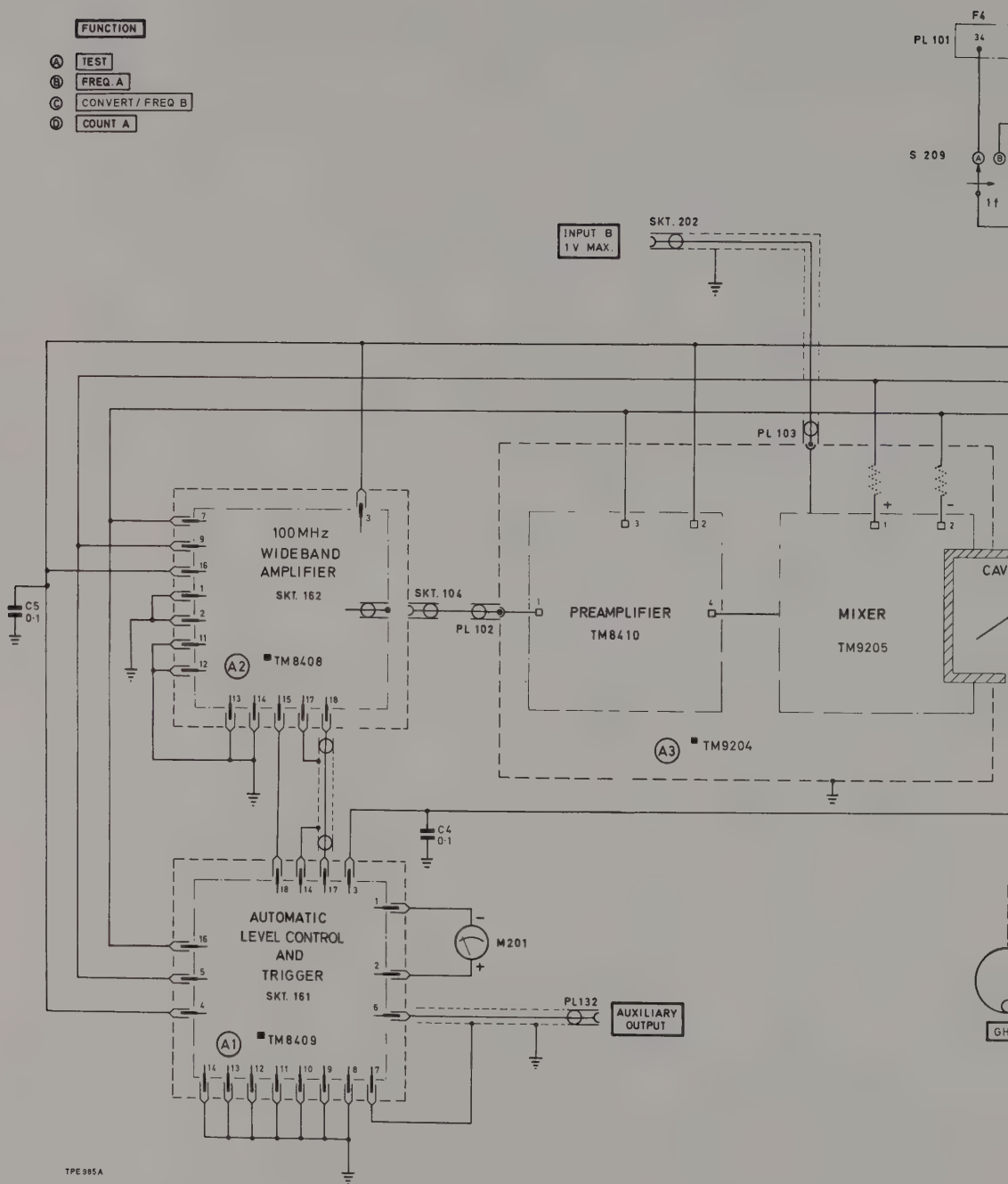


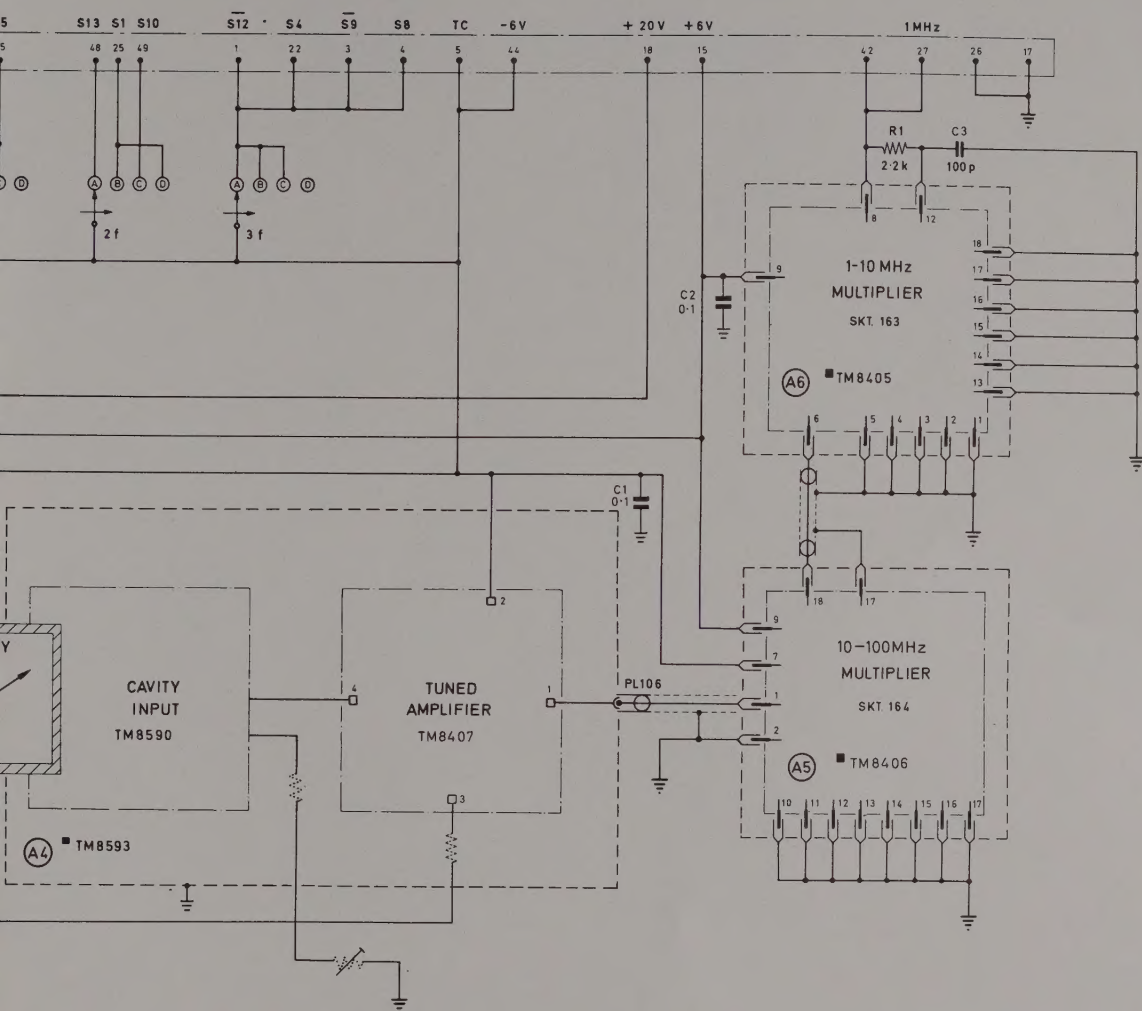
Fig. 7.2 Multipliers and tuned amplifiers, A4, A5 and A6

FUNCTION

- A TEST
- B FREQ. A
- C CONVERT / FREQ B
- D COUNT A



TPE 995A



MIXING
FREQUENCY

Fig. 7.3 Interconnecting diagram

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